

Amendment and Response

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Serial No.: 09/603,132

Confirmation No.: 3538

Filed: June 23, 2000

For: DEVICE STRUCTURES INCLUDING RUTHENIUM SILICIDE DIFFUSION BARRIER LAYERS**Remarks**

The Office Action mailed July 26, 2005 has been received and reviewed. Claims 49, 52, 57, 60, 63, 66, and 69 having been amended, and no claims having been added or canceled herein, the pending claims are claims 45-74.

Claims 49, 52, 60, and 66 have been rewritten in independent form.

Claims 57, 60, 63, 66, and 69 have also been amended to recite a chemical vapor codeposited diffusion barrier layer *on* at least a portion of the surface defining the opening. The amendment is generally supported by the originally filed specification and drawings.

Reconsideration and withdrawal of the rejections are respectfully requested.

Objection to the Drawings

The Examiner objected to the drawings under 37 C.F.R. §1.83(a) for allegedly not showing every feature of the invention specified in the claims. Specifically, the Examiner alleged that "a surface defining an opening having an aspect ratio greater than about 3" as recited in claims 60 and 66 must be shown in the drawings. Applicants respectfully traverse the rejection.

37 C.F.R. §1.83(a) states that "[t]he drawing in a nonprovisional application must show every feature of the invention specified in the claims." Applicants respectfully submit that the drawings presently on file satisfy the requirements of 37 C.F.R. §1.83(a).

Applicants respectfully submit that Figures 5 and 6 each illustrate a surface defining an opening. Specifically, Figure 5 illustrates "a RuSi_x diffusion barrier layer . . . formed on the bottom surface 185 and the one or more side walls 186 defining opening 184" (page 16, lines 9-11). Similarly, Figure 6 illustrates "a RuSi_x diffusion barrier layer formed according to the present invention on bottom surface 260 and the one or more side walls 261 defining the opening 259" (page 17, lines 19-21). Thus, Applicants respectfully submit that the drawings presently on file clearly show a surface defining an opening.

Further, Applicants respectfully submit that drawings showing "an aspect ratio greater than about 3" are not required under 37 C.F.R. §1.83(a). Specifically, 37 C.F.R. §1.83(a) states

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that "conventional features disclosed in the description and claims, where their detailed illustration is not essential for a proper understanding of the invention, should be illustrated in the drawing in the form of a graphical drawing symbol or a labeled representation (e.g., a labeled rectangular box)." Applicants respectfully submit that "an aspect ratio greater than about 3" is a conventional feature disclosed in the description (e.g., page 16, lines 4-5, which recites "[f]or example, a trench having an opening of 1 micron and depth of 3 microns has an aspect ratio of 3") and claims (e.g., claims 60 and 66), and thus, is not essential for a proper understanding of the invention.

Moreover, Applicants are not aware of any requirement for drawings to illustrate the scale of features disclosed in the claims. Further, Applicants respectfully submit that because of the small dimension of the presently claimed structures, drawings of such structures are not readily amenable to being drawn to scale. For example, Figures 5 and 6 expressly indicate (by the discontinuous lines) that the thicknesses of substrate assembly 181 and substrate 207, respectively, are not drawn to scale.

Thus, Applicants respectfully submit that the drawings presently on file are in full compliance with 37 C.F.R. §1.83(a). Reconsideration and withdrawal of the objection to the drawings are respectfully requested.

Rejection under 35 U.S.C. §112, First Paragraph

The Examiner rejected claims 69-74 under 35 U.S.C. §112, first paragraph, as containing subject matter which was allegedly not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Specifically, the Examiner stated that "[t]he specification does not describe the surface defining the opening being not a silicon containing surface" (page 3, Item 4 of the Office Action mailed July 26, 2005). Applicants respectfully traverse the rejection.

"Any negative limitation or exclusionary proviso must have basis in the original disclosure. If alternative elements are positively recited in the specification, they may be

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explicitly excluded in the claims." M.P.E.P. §2173.05(i). Applicants respectfully submit that claims 69-74 have a basis in the original disclosure sufficient to satisfy the written description requirement of 35 U.S.C. §112, first paragraph.

Specifically, claims 69-74 recite the proviso that the surface defining the opening is not a silicon containing surface. The specification clearly recites alternative elements for the surface defining the opening. For example, as discussed herein above, Figure 5 illustrates bottom surface 185 (e.g., a silicon containing surface; e.g., page 15, lines 19-20) and the one or more side walls 186 (i.e., a surface of an insulative layer of oxide material 183; e.g., page 15, lines 26-27) defining opening 184. Thus, the specification clearly recites that a surface defining an opening can be a silicon containing surface or an insulative layer of oxide material. Further, pursuant to M.P.E.P. §2173.05(i), since a silicon containing surface is positively recited in the specification, it may be explicitly excluded in the claims.

Thus, Applicants respectfully submit that claims 69-74 satisfy the written description requirement of 35 U.S.C. §112, first paragraph. Reconsideration and withdrawal of the rejection under 35 U.S.C. §112, first paragraph, are respectfully requested.

Rejections under 35 U.S.C. §102

The Examiner rejected claims 45-48 and 54-59 under 35 U.S.C. §102(b) as being anticipated by Komatsu (U.S. Patent No. 5,907,789). Applicants respectfully note that Komatsu issued May 25, 1999, which is after the August 27, 1998 priority date of the present application, and thus, is not available as art under 35 U.S.C. §102(b). However, to the extent that the rejection might be maintained under another section of 35 U.S.C. §102, Applicants respectfully traverse the rejection.

For anticipation to occur, a prior art disclosure must put the public in possession of the invention:

"In determining that quantum of prior art disclosure which is necessary to declare an applicant's invention 'not novel' or 'anticipated' within section 102, the stated

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test is whether a reference contains an 'enabling disclosure'... ." *In re Hoeksema*, 399 F.2d 269, 158 USPQ 596 (CCPA 1968). The disclosure in an assertedly anticipating reference must provide an enabling disclosure of the desired subject matter; *mere naming or description of the subject matter is insufficient, if it cannot be produced without undue experimentation. Elan Pharm., Inc. v. >Mayo Found. For Med. Educ. & Research<*, 346 F.3d 1051, 1054, 68 USPQ2d 1373, 1376 (Fed. Cir. 2003) A reference contains an "enabling disclosure" if the public was in possession of the claimed invention before the date of invention. "Such possession is effected if one of ordinary skill in the art could have combined the publication's description of the invention with his [or her] own knowledge to make the claimed invention." *In re Donohue*, 766 F.2d 531, 226 USPQ 619 (Fed. Cir. 1985).

M.P.E.P. §2121.01 (emphasis added). Applicants respectfully submit that Komatsu does not put the public in possession of the claimed invention.

Claims 45-48 and 54-59 recite a chemical vapor codeposited diffusion barrier layer, wherein the diffusion barrier layer is formed of RuSi_x , where x is in the range of about 0.01 to about 10. Applicants respectfully submit that before the date of the present invention, Komatsu would have failed to provide an enabling disclosure of a chemical vapor codeposited diffusion barrier layer formed of RuSi_x .

Specifically, Komatsu discloses "tungsten silicide (WSi_x) formed by CVD" (e.g., column 4, line 43; column 4, line 58 to column 5, line 6; column 5, line 66 to column 6, line 6; and column 6, lines 19-22). However, the only mention of a ruthenium silicide layer by Komatsu is the mere naming of such a layer:

In the method of forming a contact-hole of the present invention, in place of the metal silicide layer made of WSi_x , there may be used a metal silicide layer made of silicon and a metal such as titanium (Ti), molybdenum (Mo), tantalum (Ta), vanadium (V), chromium (Cr), cobalt (Co), nickel (Ni), zirconium (Zr), niobium (Nb), rhodium (Rh), palladium (Pd), hafnium (Hf), platinum (Pt), manganese (Mn), iron (Fe), iridium (Ir), ruthenium (Ru), osmium (Os) or rhenium (Re), which is formed by the physical vapor-phase growth method such as sputtering or deposition or the chemical vapor-phase growth method such as CVD. As for Ti, W, Mo, Ta, Pt, Re and the like, a gas containing Si such as SiH_4 and a source gas composed of the halogen compound thereof is reduced by H_2 or the like using

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CVD, to form a metal silicide film. In some cases, the organic metal compound thereof can be used to form a metal layer by CVD.
(Column 22, lines 29-44).

Although Komatsu recites possible precursors for CVD deposition of Ti, W, Mo, Ta, Pt, Re silicides ("a gas containing Si such as SiH_4 and a source gas composed of the halogen compound thereof is reduced by H_2 or the like"), Komatsu fails to disclose or suggest a single possible precursor for CVD deposition of a ruthenium silicide. For at least this reason, Applicants respectfully submit that before the date of the present invention, Komatsu would have failed to provide an enabling disclosure of a chemical vapor codeposited diffusion barrier layer formed of RuSi_x .

For at least the reason discussed herein above, Applicants respectfully submit that Komatsu fails to anticipate present claims 45-48 and 54-59. Reconsideration and withdrawal of the rejection of claims 45-48 and 54-59 as being anticipated by Komatsu are respectfully requested.

The Examiner rejected claims 45-48, 50, and 51 under 35 U.S.C. §102 as being anticipated by Matsubara et al. (U.S. Patent No. 5,122,923). Applicants respectfully traversed this rejection on pages 8-10 of the Amendment and Response submitted May 9, 2005, the remarks of which are incorporated herein by reference.

In brief, Applicants submitted that those skilled in the art would appreciate that the term "chemical vapor deposited" when used to define a layer describes a structurally different layer than when the term "sputtered" is used to define a layer. As such, the term "chemical vapor codeposited" is not merely a product-by-process limitation and must be given patentable weight in the pending claims.

In response, the Examiner asserted that "Komatsu 5,907,789 and Agostinelli et al. 5,017,551 respectively disclose . . . the two methods as interchangeable in forming the structure of a ruthenium silicide layer" (page 9, item 14 of the Office Action mailed July 26, 2005). Applicants are unclear as to the Examiner's intent in citing Agostinelli et al. in his remarks,

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because no art rejections based on Agostinelli et al. are of record. Nonetheless, Applicants earnestly disagree with the Examiner's interpretation of Komatsu et al. and Agostinelli et al.

Specifically, the Examiner points to column 22, lines 29-44 of Komatsu et al. (which have been reproduced in full herein above), which recites "a metal silicide layer made of silicon and a metal . . . , which is formed by the physical vapor-phase growth method such as sputtering or deposition or the chemical vapor-phase growth method such as CVD." Similarly, the Examiner points to column 20, lines 11-16 of Agostinelli et al., which states that "[i]t is appreciated that the barrier layer can alternatively be formed by any other convenient conventional preparation process. It is specifically contemplated to form barrier layers by sputtering, vacuum vapor deposition, and metal-organic chemical vapor deposition procedures." Although Komatsu et al. and Agostinelli et al. each recite alternative methods for making silicide layers, *there is absolutely no teaching or suggestion in either Komatsu et al. or Agostinelli et al. that layers made by these alternative processes are identical.*

In contrast, Applicants have submitted evidence to support Applicants' assertion that the term "chemical vapor deposited" when used to define a layer describes a structurally different layer than when the term "sputtered" is used to define a layer. In addition to the Declaration Under 37 C.F.R. §1.132 signed by the inventors and filed in response to the Final Office Action dated November 25, 2002, *Applicants even submitted additional supporting evidence as follows.*

Applicants wish to draw the Examiner's attention to the following documents, which support the position that those skilled in the art would appreciate that the term "chemical vapor deposited" when used to define a layer describes a structurally different layer than when the term "sputtered" is used to define a layer. *See, for example*, Wolf et al. (submitted May 9, 2005 in an Information Disclosure Statement), stating that "CVD offers several advantages over other techniques for silicide formation including, improved step coverage, *higher purity films (low O₂ content)*, and higher throughput" (page 392, last paragraph; emphasis added). Applicants respectfully submit that *higher purity films (low O₂ content)* is a structural property that could be analyzed by one of skill in the art, and moreover, that oxygen contamination in the silicide

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film also has a significant effect on the *film resistivity* (page 388, second paragraph), which is *also a structural property* that could be analyzed by one of skill in the art. For another example, Yao-Joe Yang (submitted May 9, 2005 in an Information Disclosure Statement) states that "[s]ubstrate damage is the major disadvantage" of sputtering (page 5, slide 9; *see, also*, page 6, slide 11). *However, the Examiner has neither acknowledged nor disputed this additional supporting evidence submitted concurrently with the May 9, 2005 Amendment and Response.* Thus, the Examiner's assertion that "[t]he limitation 'chemical vapor codeposited' merely recites a method of forming and does not deviate from the **structure of a diffusion barrier made of RuSi_x**" (e.g., page 9, first paragraph of the Office Action mailed July 26, 2005; emphasis in original) is *not only unsupported, but also inconsistent with the evidence of record in the present application.*

As such, Applicants respectfully submit that the term "chemical vapor codeposited" is not merely a product-by-process limitation and must be given patentable weight in the pending claims. Reconsideration and withdrawal of the rejection of claims 45-48, 50, and 51 as being anticipated by Matsubara et al. are respectfully requested.

The Examiner rejected claims 45, 46, 50, and 51 under 35 U.S.C. §102 as being anticipated by Kuroiwa et al. (U.S. Patent No. 6,239,460). Applicants respectfully traversed this rejection on pages 11-12 of the Amendment and Response submitted May 9, 2005, the remarks of which are incorporated herein by reference. In addition to the Declaration Under 37 C.F.R. §1.132 signed by the inventors and filed in response to the Final Office Action dated November 25, 2002, *Applicants submitted additional supporting evidence as follows.*

Applicants wish to draw the Examiner's attention to the following documents, which support the position that those skilled in the art would appreciate that the term "chemical vapor deposited" when used to define a layer describes a structurally different layer than a layer formed by a salicidation process. *See, for example*, Wolf et al. (submitted May 9, 2005 in an Information Disclosure Statement), stating that "CVD offers several advantages over other techniques for silicide formation including, improved step coverage, *higher purity films (low O₂*

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content), and higher throughput" (page 392, last paragraph; emphasis added). Applicants respectfully submit that *higher purity films (low O₂ content) is a structural property* that could be analyzed by one of skill in the art, and moreover, that oxygen contamination in the silicide film also has a significant effect on the *film resistivity* (page 388, second paragraph), which is *also a structural property* that could be analyzed by one of skill in the art. *However, the Examiner has neither acknowledged nor disputed this additional supporting evidence submitted concurrently with the May 9, 2005 Amendment and Response.* Thus, the Examiner's assertion that "[t]he limitation 'chemical vapor codeposited' merely recites a method of forming and does not deviate from the structure of a diffusion barrier made of RuSi_x" (e.g., page 9, first paragraph of the Office Action mailed July 26, 2005; emphasis in original) is *not only unsupported, but also inconsistent with the evidence of record in the present application.*

As such, the term "chemical vapor codeposited" is not merely a product-by-process limitation and must be given patentable weight in the pending claims. Reconsideration and withdrawal of the rejection of claims 45, 46, 50, and 51 as being anticipated by Kuroiwa et al. is respectfully requested.

Rejections under 35 U.S.C. §103**Kuroiwa et al. in view of Lee et al. '041**

The Examiner rejected claims 48, 49, 54-59, 61-65 and 67-74 under 35 U.S.C. §103 as being unpatentable over Kuroiwa et al. (U.S. Patent No. 6,239,460) and further in view of Lee et al. '041 (U.S. Patent No. 5,872,041).

Applicants respectfully submit that the cited documents do not teach or suggest all of the language recited in the present claims. Specifically, Kuroiwa et al., which has been discussed herein above, lacks, among other things, a chemical vapor codeposited RuSi_x diffusion barrier layer. Applicants respectfully submit that Lee et al. '041, which "relates to a method for fabricating the electrodes of a semiconductor capacitor" (column 1, lines 8-9), fail to cure the deficiencies of Kuroiwa et al. Thus, for at least this reason, Applicants respectfully submit that

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claims 48, 49, 54-59, 61-65 and 67-74 are patentable over Kuroiwa et al. in view of Lee et al. '041.

Further, independent claims 57 and 63 each recite a surface defining an opening having an aspect ratio greater than about 1, and a chemical vapor codeposited diffusion barrier layer on at least a portion of the surface defining the opening. Despite the Examiner's unsupported allegations to the contrary, Applicants respectfully submit that there is absolutely no disclosure in Kuroiwa et al. of *a surface defining an opening having an aspect ratio greater than about 1, and a chemical vapor codeposited diffusion barrier layer on at least a portion of the surface defining the opening.*

Moreover, Applicants note that the Examiner stated that "Kuroiwa does not disclose a silicon containing region" (page 6, lines 3-4 of the Office Action mailed July 26, 2005). Applicants do not understand this statement, as Kuroiwa et al. clearly disclose the deposition of ruthenium on a silicon containing surface (e.g., column 10, lines 48-49, reciting that "plug 111 was made of polycrystal silicon containing doped phosphorus"). Further, Kuroiwa et al. disclose that the deposition of ruthenium is followed by heat treatment to form a ruthenium silicide layer through a salicidation process. Thus, a silicon containing surface is not only disclosed by Kuroiwa et al.; Kuroiwa's disclosed *salicidation process* to form a ruthenium silicide layer actually *requires* a silicon containing surface.

In contrast, claims 69-74 recite that "the surface defining the opening is not a silicon containing surface." In view of the remarks presented herein above, Applicants respectfully submit that any suggestion by the Examiner to modify the teachings of Kuroiwa et al. to form a ruthenium silicide layer on a surface defining an opening that is not a silicon containing surface would impermissibly render the teaching of Kuroiwa et al. inoperative. *See, for example*, M.P.E.P. 2143.01, which states that "[i]f proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification." Thus, for at least these reasons, Applicants respectfully submit that claims 69-74 are patentable over Kuroiwa et al. in view of Lee et al. '041.

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Thus, for at least the reasons presented herein above, Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of obviousness of claims 48, 49, 54-59, 61-65 and 67-74 under 35 U.S.C. § 103. Reconsideration and withdrawal of the rejection under 35 U.S.C. § 103 are respectfully requested.

Kuroiwa et al. in view of Lee et al. '041, and further in view of Matsubara et al.

The Examiner rejected claims 52 and 53 under 35 U.S.C. § 103 as being unpatentable over Kuroiwa et al. (U.S. Patent No. 6,239,460) in view of Lee et al. '041 (U.S. Patent No. 5,872,041), and further in view of Matsubara et al. (U.S. Patent No. 5,122,923). Applicants respectfully traverse the rejection.

Specifically, in the present case, the deficiencies of Kuroiwa et al. in view of Lee et al. '041 have been discussed herein above. In brief, neither Kuroiwa et al. nor Lee et al. '041 disclose or suggest a chemical vapor codeposited RuSi_x diffusion barrier layer. Moreover, Applicants respectfully submit that Matsubara et al., which has been discussed herein above, also fail to disclose or suggest a chemical vapor codeposited RuSi_x diffusion barrier layer. Thus, Applicants respectfully submit that claims 52 and 53 are patentable over Kuroiwa et al. in view of Lee et al. '041, and further in view of Matsubara et al.

Moreover, in order to establish a *prima facie* case of obviousness, the references must teach or suggest all the claim limitations. *Hybritech Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 231 U.S.P.Q. 81 at 93 ("Focusing on the obviousness of substitutions and differences instead of on the invention as a whole, . . . was a legally improper way to simplify the difficult determination of obviousness."). One cannot "simply [to] engage in a hindsight reconstruction of the claimed invention, using the Applicant's structure as a template and selecting elements from references to fill the gaps." *In re Gorman*, 933 F.2d 982, 18 U.S.P.Q.2d 1885, 1888 (Fed. Cir. 1991). Further, both the suggestion for combining the teachings of the prior art to make the invention and the reasonable likelihood of its success must be founded in the prior art and not in the teachings of Applicants' disclosure. *In re Dow Chem.*, 837 F.2d 469, 473, 5 U.S.P.Q.2d 1529, 1531 (Fed. Cir. 1988). Here, the cited art neither suggests the combination of its teachings

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nor suggests the reasonable likelihood that such a combination would result in the present invention.

Furthermore, as recently reasserted in *Princeton Biochemicals, Inc. v. Beckman Coulter, Inc.* (Fed. Cir., No. 04-1493, June 9, 2005), 35 U.S.C. §103 specifically requires an assessment of the claimed invention "as a whole." This "as a whole" assessment of the invention requires a showing that an artisan of ordinary skill in the art at the time of invention, confronted by the same problems as the inventor and with no knowledge of the claimed invention, would have selected the various elements from the cited references and combined them in the claimed manner. In other words, 35 U.S.C. §103 requires some suggestion or motivation, before the invention itself, to make the new combination. See *In re Rouffet*, 149 F.3d 1350, 1355-56 (Fed. Cir. 1998).

This "as a whole" instruction in 35 U.S. §103 prevents evaluation of the invention part by part. Without this important requirement, an obviousness assessment might successfully break an invention into its component parts, then find a reference corresponding to each component. This line of reasoning would import hindsight into the obviousness determination by using the invention as a roadmap to find its prior art components. Further, this improper method would discount the value of combining various existing features or principles in a new way to achieve a new result - often the essence of invention. *Ruiz v. A.B. Chance Co.*, 357 F.3d 1270, 1275 (Fed. Cir. 2004). Simply identifying the various elements of a claim in the cited references does not render a claim obvious. *Ruiz*, 357 F.3d at 1275. Instead, 35 U.S. §103 requires some suggestion or motivation in the prior art to make the new combination. *Rouffet*, 149 F.3d at 1355-56. Applicants submit that the Examiner has engaged in an improper part by part analysis of the claimed invention.

Thus, for at least the reasons presented herein above, Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of obviousness of claims 52 and 53 under 35 U.S.C. §103. Reconsideration and withdrawal of the rejection under 35 U.S.C. §103 are respectfully requested.

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The Examiner rejected claims 60 and 66 under 35 U.S.C. §103 as being unpatentable over Kuroiwa et al. (U.S. Patent No. 6,239,460) and further in view of Lee et al. '041 (U.S. Patent No. 5,872,041) and further in view of Lee et al. '350 (U.S. Patent No. 5,897,350).

The deficiencies of Kuroiwa et al. in view of Lee et al. '041 have been discussed herein above. In brief, neither Kuroiwa et al. nor Lee et al. '041 disclose or suggest a chemical vapor codeposited RuSi_x diffusion barrier layer. Moreover, Lee et al. '350, which "relates to a memory cell structure of of (sic) semiconductor memory device" (column 1, lines 6-7), also fails to disclose or suggest a chemical vapor codeposited RuSi_x diffusion barrier layer.

Thus, for at least the reasons presented herein above, Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of obviousness of claims 60 and 66 under 35 U.S.C. §103. Reconsideration and withdrawal of the rejection under 35 U.S.C. §103 are respectfully requested.

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It is respectfully submitted that all the pending claims are in condition for allowance and notification to that effect is respectfully requested. The Examiner is invited to contact Applicants' Representatives, at the below-listed telephone number, if it is believed that prosecution of this application may be assisted thereby.

Respectfully submitted by
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CERTIFICATE UNDER 37 CFR §1.8:

The undersigned hereby certifies that the Transmittal Letter and the paper(s), as described hereinabove, are being transmitted by facsimile in accordance with 37 CFR §1.6(d) to the Patent and Trademark Office, addressed to Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on this 26th day of October, 2005, at 11:06 am (Central Time).

By: Name: Sara E. Wight